LESSON 15:
APPLICATION OF HAPLOIDS IN PLANT BREEDING

Introduction

In vitro production of haploids can solve some problems in genetic studies since gene actions are readily manifested due to a single allelic dose present in chromosomes of an entire genome. This also makes them good material for induction of mutations and various gene manipulations. Through rapid achievement of homozygous traits in double-haploids, pollen-derived haploid plants have been used in breeding and improvement of crop species. Some of the achievements include:

Releasing New Varieties through F1 Double-haploid System

Haploid breeding techniques usually involve only one cycle of meiotic recombination. However, many agronomic traits (such as the yield) are polygenically controlled. One cycle of recombination is usually insufficient for the improvement of such quantitative traits since the linkage between polygenes will not release all potential variations available in a cross. To overcome these disadvantages, the Chinese developed a method of combining anther-culture with sexual hybridisation among different genotypes of anther- derived plants. The anthers of the hybrid (F1) progeny are excellent breeding material for raising pollen-derived homozygous plants (double-haploids) in which complementary parental characteristics are combined in one generation.

Double-haploids are also useful in studies related to inheritance of qualitative traits. In breeding programmes the double-haploids derived from pollen cultures, expressed genetic variability to an extent that new varieties have been synthesised in respect of barley, brassica, rice, maize, rye, potato, pepper and asparagus. By haploid induction followed by chromosome doubling, it is possible to obtain exclusively male plants in dioecious species. An important example of this is Asparagus officinalis, in which androgenic haploids produced from male asparagus plants are either X or Y. Chromosome doubling of Y results in supermales (YY) which can be vegetatively propagated. If XX is crossed with YY plants, the progeny will be all male lines. Using this method Thevenin and Dare (1976) established hi -yielding male lines of Asparagus.

Selection of Mutants Resistant to Disease

Screening mutants with resistance to disease is of prime importance in crop improvement. Haploids provide a relatively easier system for the induction of mutations, therefore, they can be employed in rapid selection of mutants having traits for disease resistance. Some examples of using anther culture technique in mutant selection successfully are tobacco mutants resistant to black shank disease and wheat lines resistant to scab (Fusarium graminearum).

Developing Asexual Lines of Trees/Perennial Species

Chinese workers obtained a pollen-derived rubber tree taller by six metres which could then be multiplied by asexual propagation to raise several clones. Another example of using pollen-haploids in plant improvement is Poplar. Of particular interest in this tree species is that haploid seedlings selected for desired genotypes are naturally doubled as diploids after 7-8 years. This coincides with their flowering, enabling them to be both asexually and sexually propagated. Pollen derived haploid plantlets have also been obtained in other perennial woody species, such as Aesculus hippocastatnum, Citrus microcarpa, Vitis vinifera, Malus prunifolia, M. pumila, Litchi chinensis, Euphoria longan, Ponicirus trifoliata, Lycium halinifolium, L barbarium, L chinensis and Camellia sinensis.

Transfer of Desired Alien Genes

Chromosomal instability in haploids makes them potential tools for introduction of alien chromosomes or genes during wider crossing programmes. In rice, the breeding of high-yielding varieties for resistance to blast is conventionally achieved through back-cross. This is a time-consuming process and may take more than twelve years to develop a cultivar with desired resistance. Through hybridisation and anther culture, a standard pollen-plant breeding procedure can be developed in rice to introduce genes for high yield and resistance to blast in a short span of two years (examples: cv. 'Zhonghua No.8' and 'Zhonghua No. 9 released by the Institute of Crop Breeding and Cultivation in China).

Establishment of Haploid and Diploid Cell Lines of Pollen Plant

The anther culture technique was used to establish both haploid and diploid somatic cell lines of pollen plants in wheat and maize. Similarly, a haploid tobacco line resistant to methionine sulfoxomide (MSO) was selected which turned out to be identical in phenotype and effect to the toxin produced by the pathogen Pseudomonas tabaci.

Problems Associated with Haploid Production

Although haploids have been raised mainly from anther culture of a large number of species, this technique has not proved successful in respect of all genotypes of crop species. A number of problems are encountered with the induction of haploids as well as a number of other factors, which complicate the overall process of haploidisation. Some of these aspects are summarised below.

1. Often anthers fail to grow in vitro or the initial growth is followed by abortion of the embryos.
2. The tissue or callus developing from the anther generally comprises a chimera of diploid, tetraploid and haploid cells.
3. Selective cell division must take place in the haploid microspores, concomitantly restricting proliferation of

unwanted diploid and polyploid tis sues. This selective cell division is often impossible.

4. Formation of albinos in anther cultures especially with cereals can neither be avoided nor the loss of plants due to albinism reduced.
5. The technique of inducing haploids in vitro is not economically viable due to low success rate
6. Callus derived from anther or pollen in a medium supplemented with growth regulators is usually detrimental for haploid production.
7. It is difficult to isolate a haploid from a mixture of haploids and higher ploidy levels since the polyploids outgrow the haploids.
8. The doubling of haploids is time consuming and may not always result in the production of a homozygote. Double-haploids sometimes exhibit segregation in their progeny.

Conclusion

In vivo methods yield a low frequency of haploid production. On the contrary, the success achieved using in vitro methods has been spectacular and there are reports on haploids being induced by anther culture (anther androgenesis) or pollen culture from about 250 species and hybrids. The advantages offered by haploid plants over their relative diploids has attracted the attention of geneticists. This lesson, therefore, outlines the techniques and factors influencing haploid production and also discusses the principal applications of this technology to plant breeding.

Questions

1. Discuss the importance of haploids in plant breeding
2. What are the problems associated with the production of haploids?

Note